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L018,464

# PATENT SPECIFICATION

DRAWINGS ATTACHED

L018.464



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## COMPLETE SPECIFICATION

### Process of and Apparatus for Calcining Gypsum

We, THE BRITISH PLASTER BOARD (HOLDINGS) LIMITED, a British Company, of Ferguson House, 15—17 Marylebone Road, London, N.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to new and useful improvements in the process of and apparatus for calcining powdered gypsum.

The continuous calcination of gypsum has been accomplished in the past by continuously feeding gypsum rock broken to a size of about  $\frac{1}{4}$  inch screen into a rotary kiln heated by a flame or combustion gases passing through or outside the kiln. It has also been proposed to pass hot products of combustion through a thin moving bed of powdered gypsum, a continuous feed of raw gypsum and a continuous discharge of calcined gypsum being maintained.

A process has been described in which gypsum is pumped by means of a screw conveyor into the bottom of a closed kettle and discharged continuously from the top, the products of combustion of the fuel used to heat the exterior of the kettle and tubes passing through it being passed over the top of the plaster in the kettle and out of the kettle through the discharge pipe for the calcined plaster.

Such a process must employ pumps to force the raw gypsum into the kettle against the head of plaster in the kettle. The presence of such pumps is, however, undesirable as they have a tendency to become blocked.

It has now been found that satisfactory continuous calcination can be achieved by heating pulverulent gypsum in a calcination vessel and continuously introducing further pulverulent gypsum into the upper region of the vessel to discharge calcined material from the lower region of the vessel by displacement

through a rising conduit leading from the said lower region. Such displacement is made possible by the fluidisation of the mass which occurs in the vessel, as explained below.

In the preferred embodiments of the invention, the evolution of further water vapour is maintained in the rising conduit to enhance the degree of fluidisation of the material being discharged. In this way the operation of the vessel and in particular the free passage of the calcined material up the conduit is greatly enhanced.

As the raw gypsum is added to the top of the mass in the vessel, a corresponding quantity of calcined material is displaced from the bottom of the vessel due to the head of material in the vessel and is so discharged. The discharge conduit may conveniently lead to a weir over which the discharged material flows. Alternatively, the discharged material may be mechanically removed from the upper end of the discharge conduit, for example by a screw conveyor.

In the process of calcining powdered gypsum to hemihydrate approximately 15% of the weight of the gypsum is driven off in the form of steam and when a mass of the material is present this steam has the effect of fluidizing the mass, which appears to boil and in this state has the flow properties of a fluid.

When the process of calcination to hemihydrate is complete the boiling almost ceases and if heating is continued the temperature of the mass increases. Continued heating will cause the mass of hemihydrate to begin to boil a second time at some more elevated temperature (dependent upon the ambient humidity conditions and various impurities in the gypsum) and this process will continue, there being a hiatus in the rate of temperature increase. Continued heating again results in a sharp rise in temperature indicating that the remaining 5% of water of crystallisation has been substantially removed. The mass then

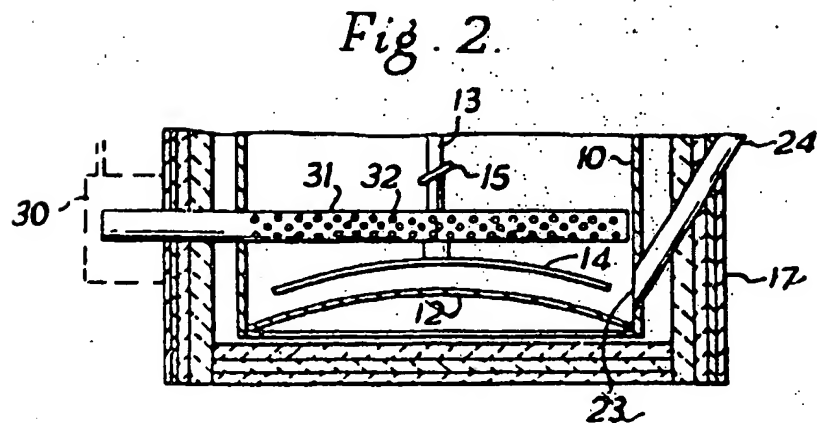
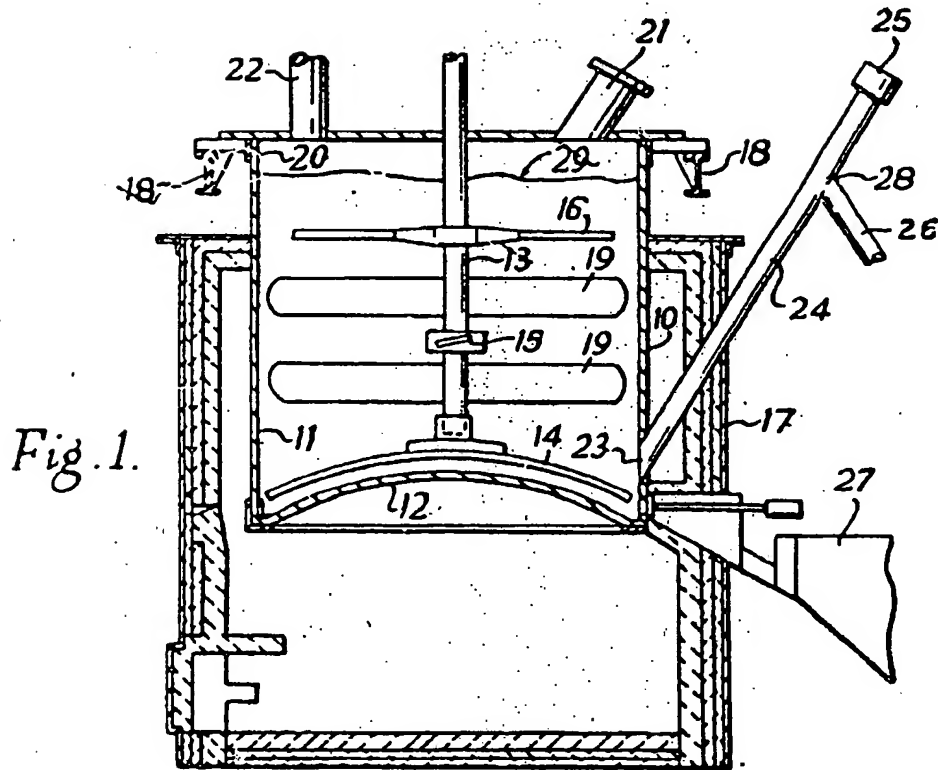
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COMPLETE SPECIFICATION.

1 SHEET

This drawing is a reproduction of the Original on a reduced scale



consists almost entirely of soluble anhydrite or "second-boil" plaster.

In putting the invention into practice the mass of plaster is brought to the state of calcination to hemihydrate by externally heating until the "boil" settles down. In the conventional batch process in a "Boiler" the mass would be dumped by opening a valve in the side of the kettle adjacent to the bottom. The mass, although boiling less vigorously, is still in a fluid condition and readily flows out of the kettle. According to the invention, however, instead of the kettle being emptied at the completion of calcination to hemihydrate, additional raw ground gypsum is added continuously to the top of the mass in measured quantity and the introduction of this raw material immediately causes the mass to boil vigorously due to the sudden release of steam on contact with the hemihydrate in the mass, which is at a temperature in excess of the normal boiling temperature for the conditions existing in the mass. Owing to the intimate contact between the "super-heated" hemihydrate and the raw gypsum, calcination takes place very rapidly and provided the temperature is maintained sufficiently above the normal "boiling" temperature of the gypsum the overflow from the stand pipe will consist of commercially satisfactory calcined hemihydrate.

It has been found that, provided heat is supplied to the mass at a rate which corresponds to the heat requirements to calcine the raw gypsum added, the material passing into the discharge conduit is satisfactorily calcined and the temperature of the mass remains substantially constant. The mass of calcined gypsum has the effect of absorbing fluctuations in the rate of heating and in the rate of feed of raw gypsum, by providing a reservoir of heat and a dispersal volume for the raw gypsum so that it is calcined before it leaves the mass. The mass of gypsum at calcining temperature also provides a large contact area through which the raw gypsum is heated and as a result the calcining process takes place quickly.

By means of the present invention it is possible to produce either hemihydrate plaster, sometimes known as "first boil" plaster, or beta anhydrite or soluble anhydrite, sometimes known as "second boil" plaster.

It has been found that the output of a conventional kettle, as modified in accordance with the present invention and operated continuously, can be considerably increased without damage to the furnace or other parts of the kettle and that there is a considerable saving in fuel for any given production of plaster.

The invention also makes easier the control of the process by automatic means. Thus when the desirable temperature of the mass has been decided, the rate of feed of raw gypsum can be easily controlled to maintain

this temperature with a constant rate of heating by conventional controls. Alternatively the rate of heating can be varied with a constant rate of feed of raw gypsum to maintain the desired temperature. Such a control easily maintains constant conditions of calcination leading to a uniformly calcined product.

In a modifier form of the invention, hot gases are introduced into the bottom of the mass of calcined gypsum to provide the necessary heat for calcination and to assist in the fluidization of the mass. The preferred hot gases are the products of combustion of a gaseous fuel (although the products of combustion of any clean burning fuel can be used) and these should be introduced into the mass of calcined gypsum at the bottom of the vessel, at a pressure slightly above the pressure of that exerted by the fluidized mass at the depth of introduction of the hot gases.

In this modification the introduction of the hot gases assists the released steam in maintaining fluidization of the mass and it is possible to maintain the fluidized state of the mass through the hemihydrate state to the soluble anhydrite stage of calcination. When this modification of the invention is practised, the lower limit of temperature is reduced to 220°F. owing to the reduced partial pressure of water vapour in the atmosphere within the vessel.

Processes and apparatus embodying the invention will now be described by way of example, reference being had to the accompanying drawings in which:—

Figure 1 is a diagrammatic vertical section of a conventional plaster kettle modified in accordance with the invention.

Figure 2 is a partial vertical section of a plaster kettle constructed in accordance with the modification of the invention.

In the drawing, like reference characters indicate corresponding parts in the different Figures.

The cylindrical calcining kettle 10 shown in Fig. 1 includes side walls 11, a convex base 12, a centrally located, power-driven agitator shaft 13, and agitator blades 14, 15 and 16 situated upon the shaft 13. The kettle 10 is suspended within a combustion chamber 17 by means of two transverse members 18 extending above the combustion chamber, cross flues 19 extending through the kettle 10, facilitating the transfer of heat from the combustion chamber to gypsum within the kettle.

The upper end 20 of the kettle is closed and is provided with a variable feed inlet 21 connected to a mineral feed bin (not shown). A vent 22 is connected to the top of the kettle to release steam to atmosphere through a dust extractor (not shown).

Near the base of the kettle, an outlet 23 is provided to which is connected an upwardly

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and outwardly inclined stand pipe 24, of, say, eight inches diameter, the upper end 25 of which extends above the top 20 of the kettle.

Extending from and communicating with the stand pipe 24, is a downwardly and outwardly inclined delivery pipe 26 which leads to a conventional hot pit storage area 27. The point of communication of the delivery pipe 26 with the stand pipe 24 is indicated at 28 and it will be observed that this is below the level of the top 20 of the calcining kettle 10. In fact, it is desirable that the point 28 be approximately 18 inches below the top of the kettle.

In operation, the kettle while being heated is slowly filled with raw gypsum rock by way of the inlet 21 to a level approximately indicated at 29. Once the contents of the kettle have been calcined and have reached the desired temperature, a continuous feed of raw gypsum rock is passed through the inlet 21 from the mineral bin. The calcined gypsum rock become in effect fluidized and acquires flow characteristics similar to those of semi-fluids. Consequently as soon as additional raw material is fed through the inlet into the kettle, the calcined product overflows from the stand pipe 24 and flows down the delivery pipe 26 to the hot pit 27 in a quantity corresponding to the amount of raw material passing in through the inlet.

By adjustment of the rate of feed, it is arranged that only calcined gypsum passes through the stand pipe 24 to the delivery pipe 26 thus achieving a continuous process which eliminates the time wasting filling and dumping of the calcining kettles.

In a modification shown in Figure 2, the source of heat takes the form of a gas or other suitable fuel burner 30 situated adjacent to the base of the kettle 10. A distribution tube or pipe 31 extends from the burner 30, through the wall 11 of the kettle and spans the base of the kettle. This pipe or tube is perforated as at 32 to permit the hot gases of combustion to discharge into the interior of the kettle and through the gypsum therein thus not only calcining the gypsum but also assisting in the fluidization of the mass in the kettle. As mentioned previously, the pressure of the discharged gases through pipe 31 should be greater than the pressure exerted by the mass of gypsum surrounding the pipe. The products of combustion may also be circulated round the outside of the kettle shell to assist in heating, as in conventional kettles.

As an example of the operation of the process of the invention, ground ray gypsum 90%, of which would pass a 100 mesh screen (B.S.S. 410; 1943) and having a calcium sulphate content of approximately 86%, the balance consisting mostly of limestone, was continuously calcined at 300°F. at a rate of

10.5 tons per hour. The resulting plaster had the following approximate analysis.

Hemihydrate	- - -	77.2%
Soluble Anhydrite	- - -	3.3%
Dihydrate	- - -	3.6%

The same material calcined at 330°F. had the following approximate analysis.

Hemihydrate	- - -	67.0%
Soluble Anhydrite	- - -	13.1%
Dihydrate	- - -	3.5%

It has been found that when a conventional kettle is adapted to operate according to the present invention one or more of the agitator blades can be dispensed with, thus reducing the power requirement for driving the agitator. It is preferred that the bottom scraper (shown at 14 in Figs. 1 and 2) should be retained, but the top stirrer (16 in Fig. 1) can be omitted without impairing the quality of the product.

As indicated above, the operation of the kettle and in particular the free passage of the hemihydrate material up the discharge conduit or stand pipe is greatly enhanced when the conduit or stand pipe is maintained at a temperature above the equilibrium temperature of the hemihydrate-anhydrite conversion (which is greater than that of gypsum-hemihydrate conversion) to maintain the continued evolution of steam in the conduit or stand pipe. Where the stand pipe extends within the flue of the kettle this result is automatically achieved. Where a discharge conduit is not in contact with, or is insulated from, the hot gases of the combustion chamber, it may be found desirable to insert a small heater, for example an electrical heating element, near the bottom of the pipe. Alternatively the fluidisation of the material in the discharge conduit can be improved by the introduction of air into the lower part of the conduit, which by lowering the partial pressure of the water vapour also promotes the further evolution of steam.

The constructions shown in the drawing may be modified in numerous ways. Thus, the discharge pipe may extend within the kettle from an opening near the base of the kettle to a point in the upper part of the kettle at which level an opening may be made in the wall of the kettle for the passage therethrough of the discharge pipe. By this means the making of an opening in the lower part of the kettle is avoided.

In a further modification, the discharge pipe extends vertically inside the kettle and terminates at its upper end in a closed portion of enlarged diameter from which a horizontal pipe, fitted with a screw conveyor, extends through the side of the kettle at a level approximately the same as that of the mass of material in the kettle. In operation, the addition of raw gypsum onto the top of the mass of material in the kettle causes the displacement of a corresponding quantity of

calcined gypsum up the discharge pipe, the uppermost material in the discharge pipe thus entering the horizontal pipe whence it is removed by the screw conveyor. It should be noted that this conveyor serves merely to remove material entering the horizontal pipe and neither forms a seal to this pipe nor is responsible for the entry of material into or its passage up the discharge pipe.

#### WHAT WE CLAIM IS:—

1. A process of calcining gypsum by heating pulverulent gypsum in a calcination vessel, in which further pulverulent gypsum is continuously introduced into the upper region of the vessel and calcined material is thereupon discharged from the lower region of the vessel by displacement through a rising conduit leading from the said lower region.

2. A process of calcining gypsum in which pulverulent gypsum is heated in a calcination vessel, the material in the vessel being maintained in a fluid condition solely by the water vapour evolved during calcination, further pulverulent gypsum is continuously introduced into the upper region of the vessel and calcined material is thereupon discharged from the lower region of the vessel by displacement through a rising conduit leading from the said lower region.

3. A process according to Claim 2 in which the calcined material displaced up the rising conduit flows over a weir situated at substantially the same level as the top of the material in the vessel.

4. A process according to claim 2 or 3 in which the rate of addition of further gypsum is so related to the heat input that the temperature of material in the vessel remains substantially constant.

5. A modification of the process defined in any of Claims 2 to 4 in which hot gases are introduced into the lower region of the calcination vessel to heat the gypsum and to assist in fluidising the material in the vessel.

6. A process according to any of Claims 2 to 4 in which the material in the vessel is mechanically agitated.

7. A process according to Claim 1 or 2 in which the evolution of water vapour is maintained in the rising conduit to enhance the degree of fluidisation of the material being discharged.

8. A process of calcining gypsum in which pulverulent gypsum is heated in a calcination vessel by hot gases introduced into the lower region of the vessel, the material in the vessel being fluidised by the hot gases together with the water vapour evolved during calcination, further pulverulent gypsum is continuously introduced into the upper region of the vessel and calcined material is thereupon discharged from the lower region of the vessel by displacement through a rising conduit leading from the said lower region, the

material in the rising conduit being further fluidised by the evolution of water vapour within the conduit.

9. A process according to Claim 7 or 8 in which air is introduced into the lower part of the rising conduit.

10. A process according to Claim 7 or 8 in which the material in the conduit is further heated to bring about the evolution of further water vapour.

11. A process according to any of Claims 7 to 10 in which the calcined material displaced up the rising conduit flows over a weir situated at substantially the same level as the top of the material in the vessel.

12. A process according to any of Claims 7 to 10 in which the rate of addition of further gypsum is so related to the heat input that the temperature of material in the vessel remains substantially constant.

13. A process according to any of Claims 1 to 10 in which the calcined material displaced up the rising conduit is removed from the conduit by mechanical conveyor means at substantially the same level as the top of the material in the vessel.

14. A process of calcining gypsum substantially as described with reference to Fig. 1 of the accompanying drawing.

15. A process of calcining gypsum substantially as described with reference to Fig. 2 of the accompanying drawing.

16. Calcined gypsum prepared by a process according to any of the preceding claims.

17. Calcination apparatus comprising a calcination vessel, means for heating calcinable material contained therein to calcination temperature, an inlet opening in the upper part of the vessel, and a rising discharge conduit in communication at its lower end with the lower region of the vessel and adapted for the passage of calcined material in a fluid condition when displaced up the conduit by the introduction of pulverulent calcinable material through the inlet.

18. Apparatus according to claim 17 including a mechanical agitator for agitating the contents of the vessel.

19. Apparatus according to claim 17 or 18 in which the calcination vessel is externally heated.

20. Apparatus according to any of claims 17 to 19 including a downwardly directed delivery pipe connected to the rising conduit at a level substantially the same as the normal level of material in the vessel and forming a weir to control the discharge of material from the vessel.

21. Apparatus according to any of claims 17 to 19 including mechanical conveying means in communication with the rising conduit at a level substantially the same as the normal level of material in the vessel, whereby calcined material rising in the conduit can be removed from the conduit.



22. Apparatus according to claim 21 in which the rising conduit is located inside the vessel.

5 23. Apparatus according to any of claims 17 to 22 including means for further heating material within the discharge conduit.

24. Apparatus according to any of claims 17 to 22 including means for introducing air into the lower part of the rising conduit.

10 25. Calcination apparatus comprising a calcination vessel, means for introducing hot gases into the lower region of the vessel to heat pulverulent calcinable material therein and fluidise the material, an inlet opening in the  
15 upper part of the vessel and a rising discharge conduit in communication at its lower end with the lower region of the vessel and adapted for the passage of calcined material in a fluid condition when such material is displaced up the conduit by the introduction of  
20 further pulverulent calcinable material through the inlet.

26. Apparatus according to claim 25 including a downwardly directed delivery pipe connected to the rising conduit at a level substantially the same as the normal level of material in the vessel and forming a weir to control the discharge of material from the vessel.

30 27. Apparatus according to claim 25 or 26 including a perforated tube in the lower region of the vessel and a burner connected to the tube, whereby hot combustion gases can be introduced into the vessel.

35 28. Apparatus according to any of claims 25 to 27 including a mechanical agitator for agitating the contents of the vessel.

40 29. Apparatus for calcining gypsum comprising a calcination vessel, means for introducing hot gases into the lower region of the vessel to heat powdered gypsum contained therein and to bring it into a fluid condition, an inlet opening at the upper end of the vessel, a rising discharge conduit in communication at its lower end with the lower region  
45 of the vessel and adapted for the passage of calcined material in a fluid condition when such material is displaced up the conduit by the introduction of powdered gypsum through the inlet, and means for further heating  
50 material within the rising conduit.

30. Apparatus for calcining gypsum comprising a calcination vessel, means for introducing hot gases into the lower region of the vessel to heat powdered gypsum contained  
55 therein and to bring it into a fluid condition, an inlet opening at the upper end of the vessel, a rising discharge conduit in communication at its lower end with the lower region of the vessel and adapted for the passage of  
60 calcined material in a fluid condition when such material is displaced up the conduit by the introduction of powdered gypsum through the inlet, and means for introducing air into the lower part of the discharge conduit.  
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31. apparatus according to claim 29 or 30 including a perforated tube in the lower region of the vessel and a burner connected to the tube, whereby hot combustion gases  
70 can be introduced into the vessel.

32. Apparatus according to any of claims 29 to 31 including a downwardly directed pipe connected to the rising conduit at a level substantially the same as the normal level of  
75 material in the vessel and forming a weir to control the discharge of material from the vessel.

33. Apparatus according to any of claims 29 to 31 including mechanical conveying means in communication with the rising conduit at a level substantially the same as the  
80 normal level of material in the vessel, whereby calcined material rising in the conduit can be removed from the conduit.  
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34. Apparatus according to claim 33 in which the rising conduit is located inside the vessel.

35. Apparatus for calcining gypsum substantially as described with reference to and as shown in Figure 1 of the accompanying  
90 drawings.

36. Apparatus for calcining gypsum substantially as described with reference to and as shown in Fig. 2 of the accompanying drawings.  
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